APPENDIX C
NATURAL GAS COMBINED CYCLE UNITS

1.0 INTRODUCTION

This appendix includes data gathered on natural gas turbine combined cycle units. The objective of this exercise was to present the relationship between the development of the technology over time with respect to the capital cost. The relationship of technology maturity to price per kW could then be applied to the development of the clean coal technology presented in the main portion of this document.

This presentation of data on natural gas turbine combined cycle plants is based on information available from various sources. No attempt was made in this study to develop operating costs. The Utility Data Institute, which provided a majority of the costing information, provides capital cost data in the year dollars the plant was constructed. There is no scope breakdown of the capital cost.

2.0 DATA

Cost data for natural gas turbine combined cycle facilities were gathered from various sources. Figure 1 presents these costs for all gas turbine combined cycle facilities, regardless of size, levelized to 1996 constant dollars and a 1.0 labor factor.

Various attempts were made to normalize the data presented in Figure 1 to determine a predictable trend, rather than the scatter shown in Figure 1. Figure 2 shows the cost of the facility in relation to the year it was built. The data are levelized to 1996 constant dollars and a 1.0 labor factor.

Further attempts were made to segregate the data. Many gas turbine facilities are built on sites that currently have a power-producing turbine (gas, coal or oil) where the infrastructure facilities already exist. The cost of these facilities is deceivingly low because the reported costs do not include a complete facility. Figure 3 presents natural gas combined cycle facilities between 0 and 50 MWe, built on greenfield plant sites. The costs are levelized to 1996 constant dollars and a

1.0 labor factor. This figure shows the year the plant was built versus the cost of the facility. Figure 4 presents natural gas combined cycle facilities between 50 and 100 MWe, built on greenfield plant sites. The costs are levelized to 1996 constant dollars and a 1.0 labor factor. This figure shows the year the plant was built versus the cost of the facility. Figure 5 presents the natural gas combined cycle facilities between 100 and 150 MWe, built on greenfield sights. The costs are levelized to 1996 constant dollars and a 1.0 labor factor. This figure shows the year the plant was built versus the cost of the facility. Figure 6 presents natural gas combined cycle facilities between 150 and 250 MWe, built on greenfield plant sites. The costs are levelized to 1996 constant dollars and a 1.0 labor factor. This figure shows the year the plant was built versus the cost of the facility. Figure 7 presents natural gas combined cycle facilities larger than 250 MWe, built on greenfield plant sites. The costs are levelized to 1996 constant dollars and a 1.0 labor factor. This figure shows the year the plant was built versus the cost of the facility.

Figure 8 presents data for natural gas combined cycle facilities between 0 and 50 MWe that were built as an extension to an existing facility. . The costs are levelized to 1996 constant dollars and a 1.0 labor factor. This figure shows the year the plant was built versus the cost of the facility. Figure 9 presents data for natural gas combined cycle facilities between 50 and 100 MWe that were built as an extension to an existing facility. The costs are levelized to 1996 constant dollars and a 1.0 labor factor. This figure shows the year the plant was built versus the cost of the facility. Figure 10 presents data for natural gas combined cycle facilities between 100 and 150 MWe that were built as an extension to an existing facility. The costs are levelized to 1996 constant dollars and a 1.0 labor factor. This figure shows the year the plant was built versus the cost of the facility. Figure 11 presents data for natural gas combined cycle facilities between 150 and 200 MWe that were built as an extension to an existing facility. The costs are levelized to 1996 constant dollars and a 1.0 labor factor. This figure shows the year the plant was built versus the cost of the facility. Figure 12 presents data for natural gas combined cycle facilities larger than 250 MWe that were built as an extension to an existing facility. The costs are levelized to 1996 constant dollars and a 1.0 labor factor. This figure shows the year the plant was built versus the cost of the facility.

Figure 13 exhibits the labor cost factor by region of the United States. This figure illustrates the differences in the labor rate depending on the region. Information from Figure 13 was used to adjust all costs presented to the national average or a 1.0 labor cost factor.

3.0 ANALYSIS

As previously stated, attempts were made to normalize all the data. To normalize for the region that the plant was built in, the labor factors presented in Figure 13 were utilized to equate the plant to a national average labor factor. All cost data gathered from published sources are in the year dollars that the plant came on line. These costs were escalated to 1996 constant dollars by use of the Handy-Whitman formula.

Figures 6 and 7 show a correlation between plant size and cost. Notice the Y-axis on Figures 6 and 7 has smaller scales than those on the previous two plots. Figures 8 through 12 also have significantly lower costs than those shown in Figures 4 through 7. This is due to the fact that the facility infrastructure, the incoming water, the wastewater treatment, the administration buildings, compressed gases, etc. are already provided with the existing facility.

Plant costs are dependent on technology, time frame, and site. Increasing environmental regulations cause plants to add more equipment (e.g., NOx injection and possibly SCR systems), lose potential capacity, and lose efficiency. Advanced technologies may have a higher capital cost, and be incorporated into the facility. These technologies will reduce operating costs, thereby reducing production costs; however, the data presented herein are solely a presentation of capital costs. The gas turbine that was used will have an effect on the capital cost. The time frame in which the plant was built could have a significant impact on the capital cost, and the use of union or nonunion labor will also have a significant impact. The location in which the plant is built could also have a significant impact other than the labor rate, which we have normalized, because construction techniques differ depending upon the region. In the South, structures may be left open, and heat tracing is not required. However, in the North, structures are enclosed, and the facility requires more insulation, as well as heat tracing or freeze protection.

The most significant factor influencing the data presented herein is the scope of the costs reported. We have no way of equalizing all costs reported to include similar items. Permitting and licensing may or may not be included. Civil amenities (e.g., fence, road, railway, geotechnical liners, etc.) may or may not be included.

Limited historical information was available for the international units. Most of the data presented are cost estimated data for current or future construction.

4.0 CONCLUSION

The data presented are capital cost data, with little supporting information. All attempts at normalizing or levelizing the data to get a true trend analysis failed. The data are historical, which provides relationships between data points; however, to get a true concept of the power plant development of the last seven years, more information is required. The relationship between technology maturity and capital cost was not shown in the data gathered.

Figure 1

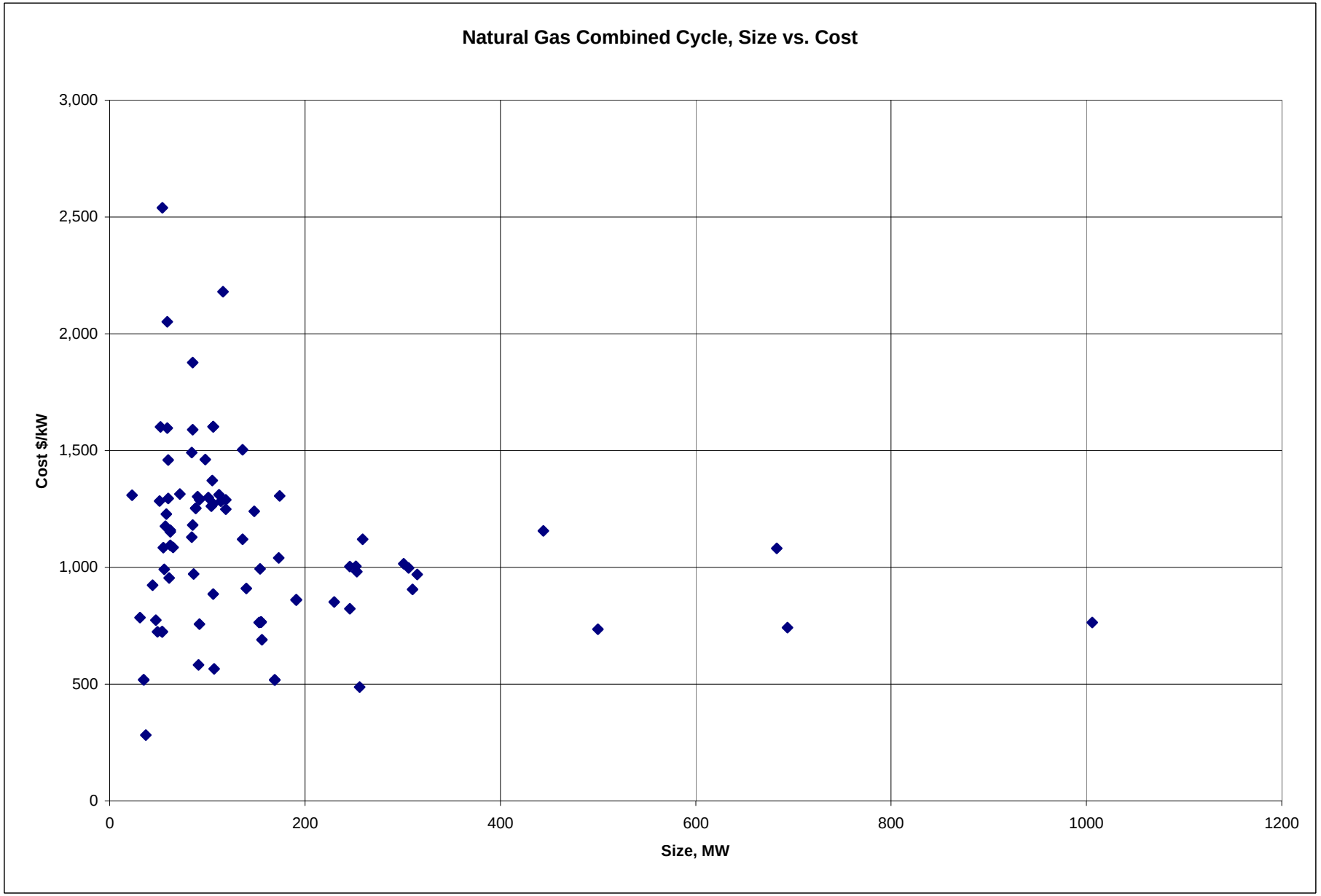
Natural Gas Combined Cycle, Size vs. Cost
Cost $/kW
3,000
2,500
2,000
1,500
1,000
500
0
0
200
400
600
800
1000
1200
Size, MW

Figure 2

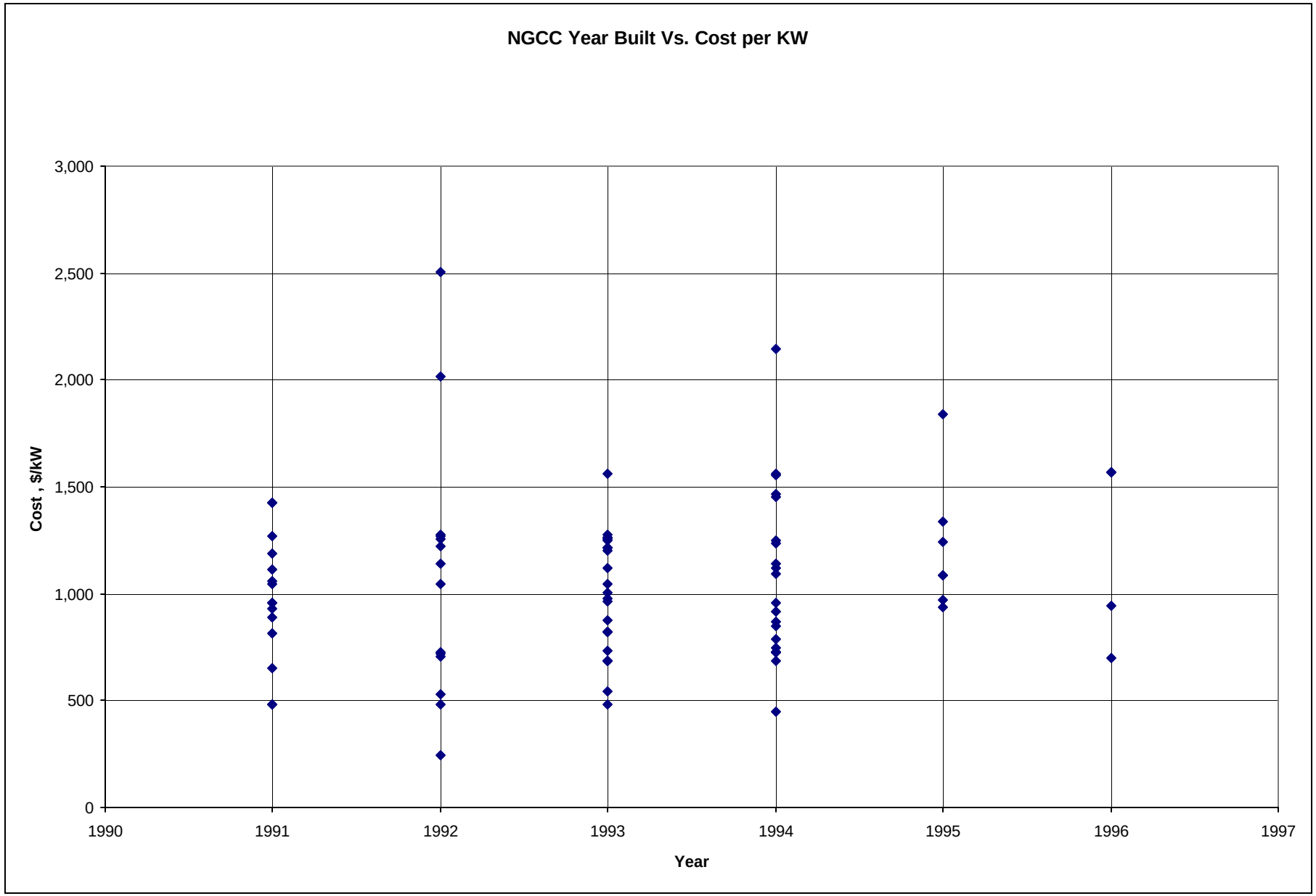
NGCC Year Built Vs. Cost per KW
Cost , $/kW
3,000
2,500
2,000
1,500
1,000
500
0
1990
1991
1992
1993
1994
1995
1996
1997
Year

Figure 3

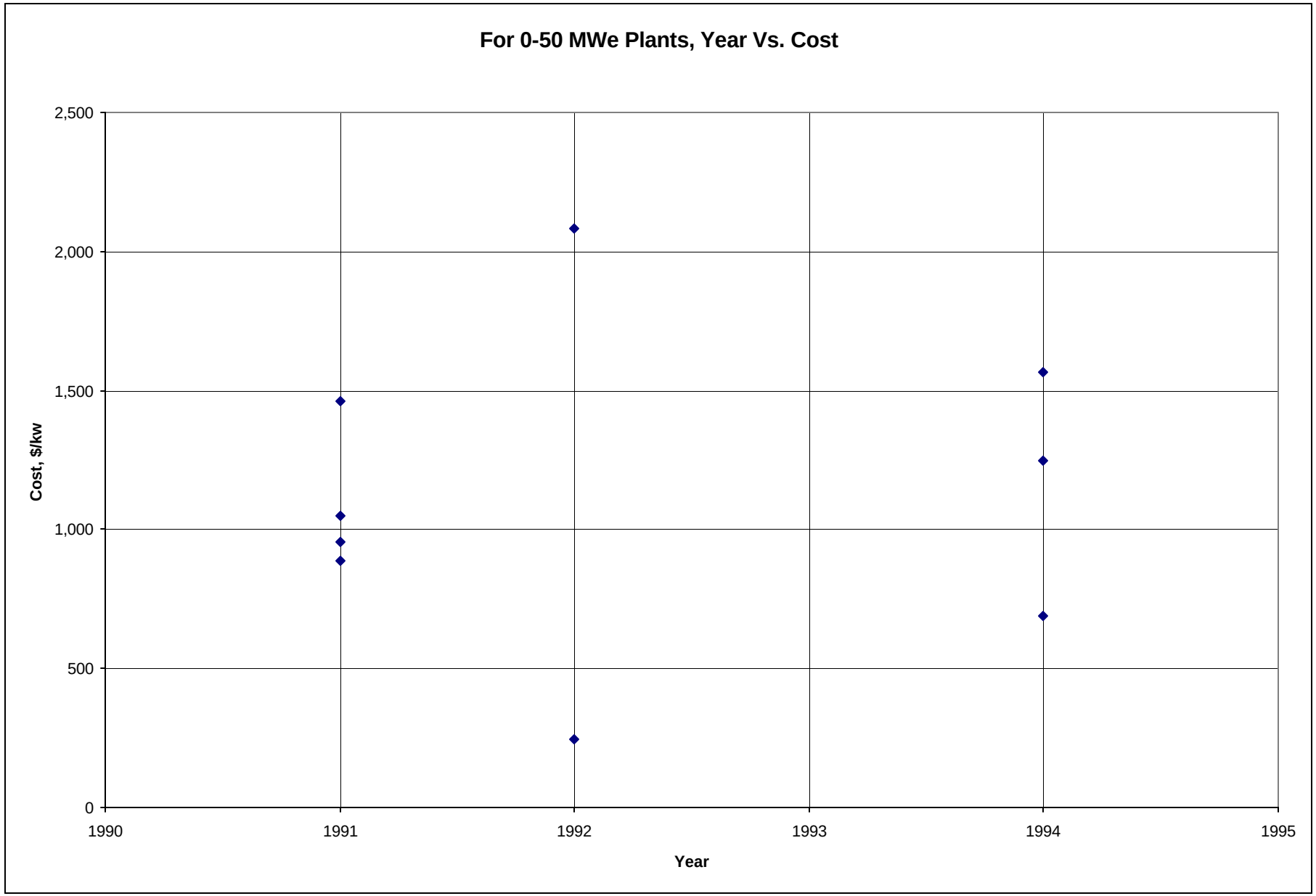
For 0-50 MWe Plants, Year Vs. Cost
2,500
2,000
1,500
1,000
500
0
Cost, $/kw
1990
1991
1992
1993
1994
1995
Year

Figure 4

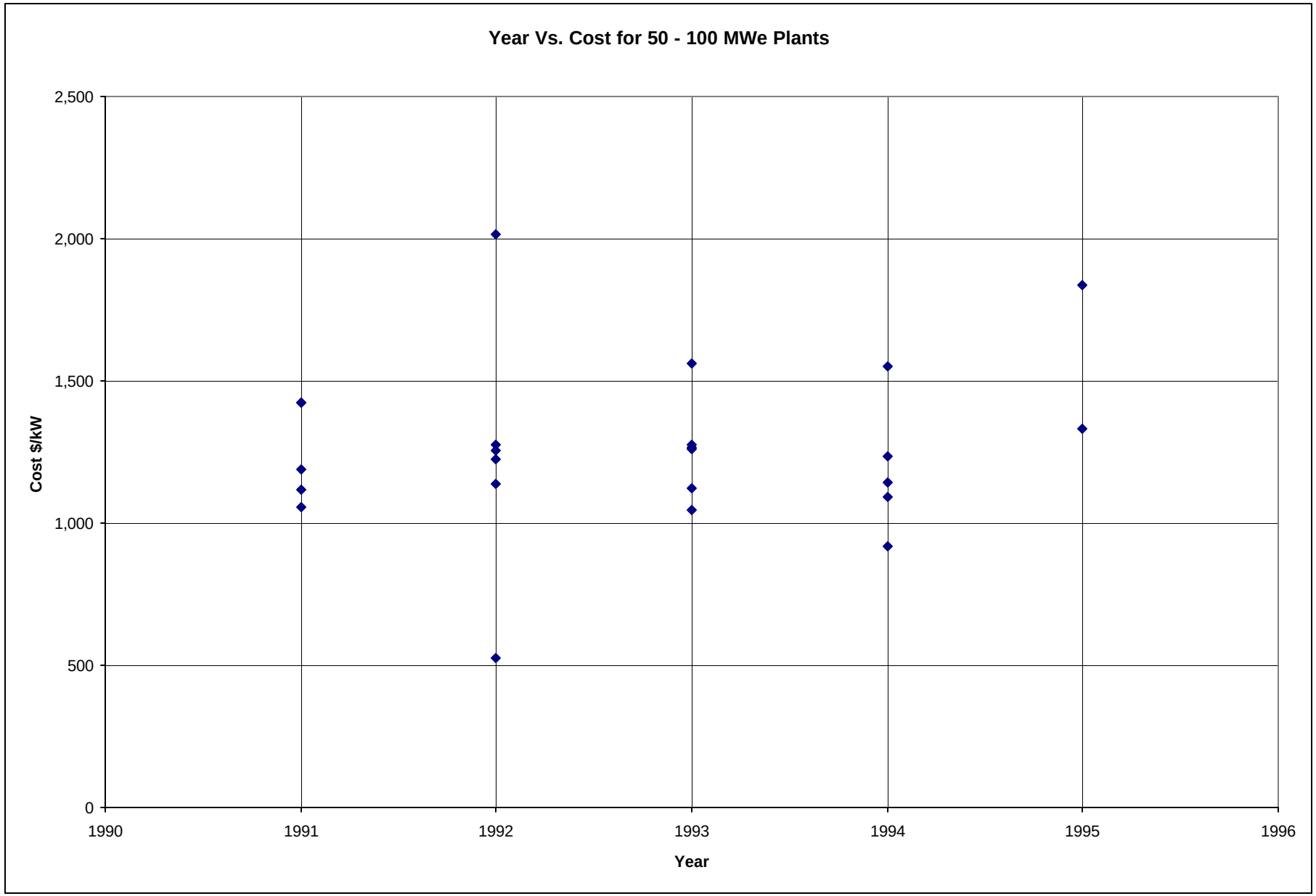
Year Vs. Cost for 50 - 100 MWe Plants
Cost $/kW
2,500
2,000
1,500
1,000
500
0
1990
1991
1992
1993
1994
1995
1996
Year

Figure 5

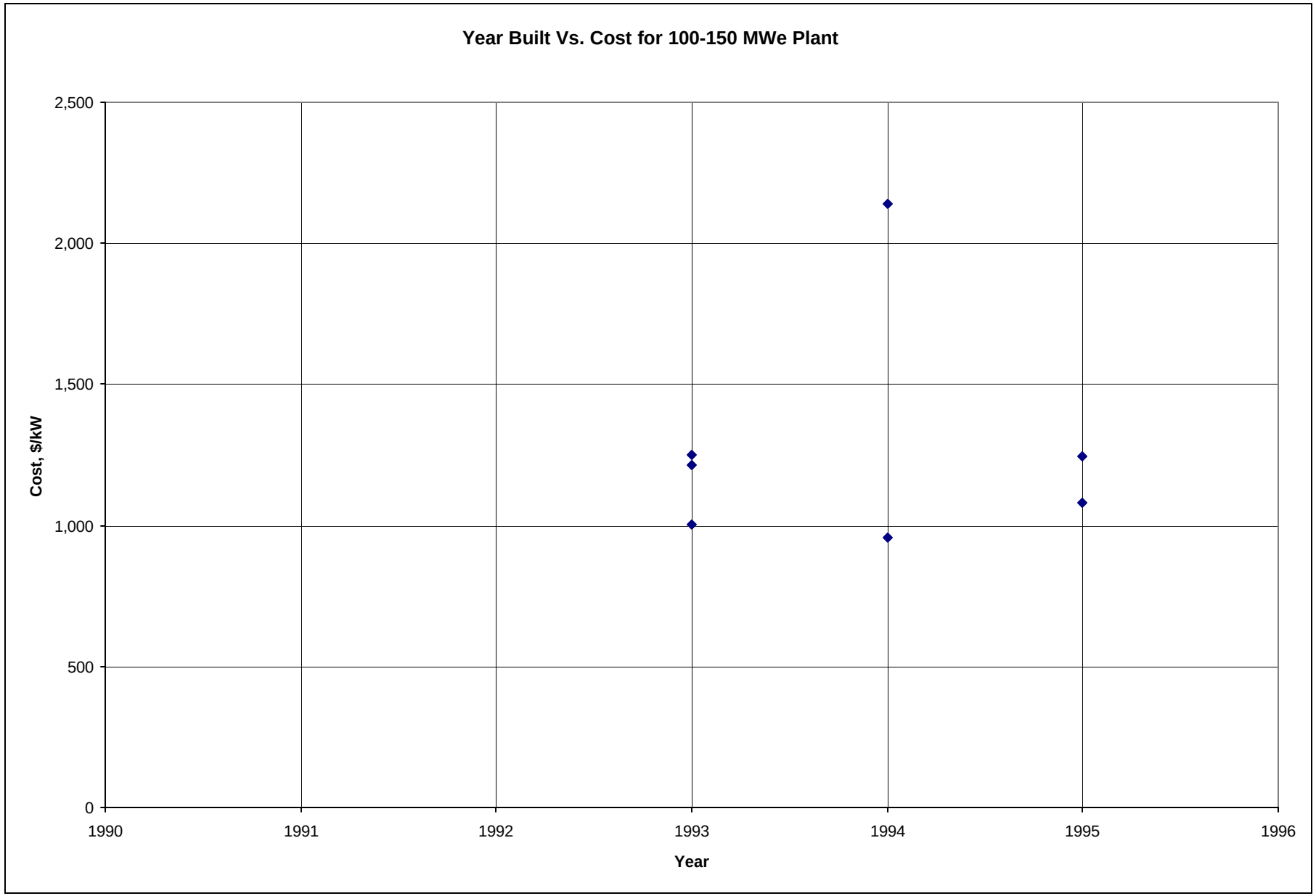
Year Built Vs. Cost for 100-150 MWe Plant
2,500
2,000
1,500
1,000
500
0
Cost, $/kW
1990
1991
1992
1993
1994
1995
1996
Year

Figure 6

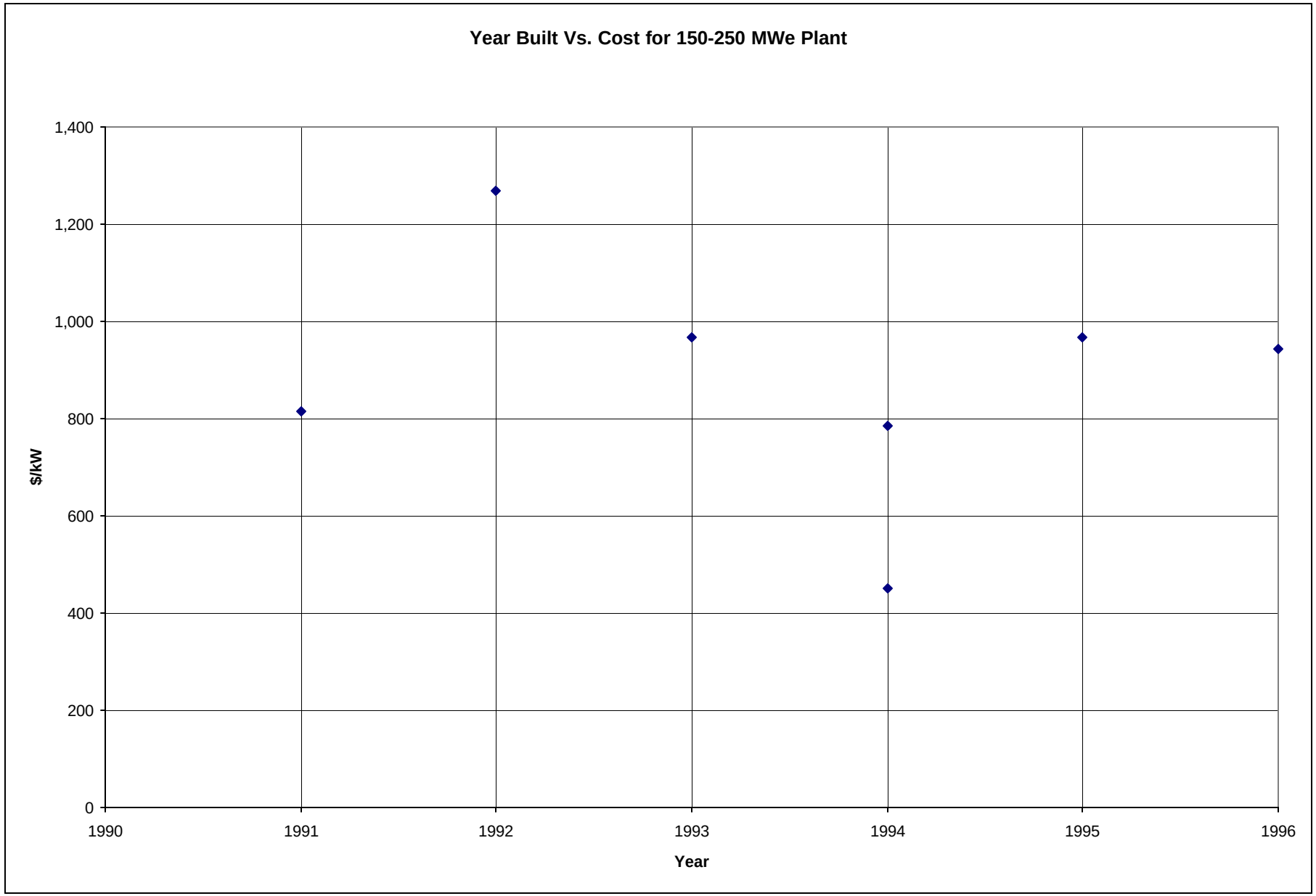
Year Built Vs. Cost for 150-250 MWe Plant
1,400
1,200
1,000
800
600
400
200
0
$/kW
1990
1991
1992
1993
1994
1995
1996
Year

Figure 7

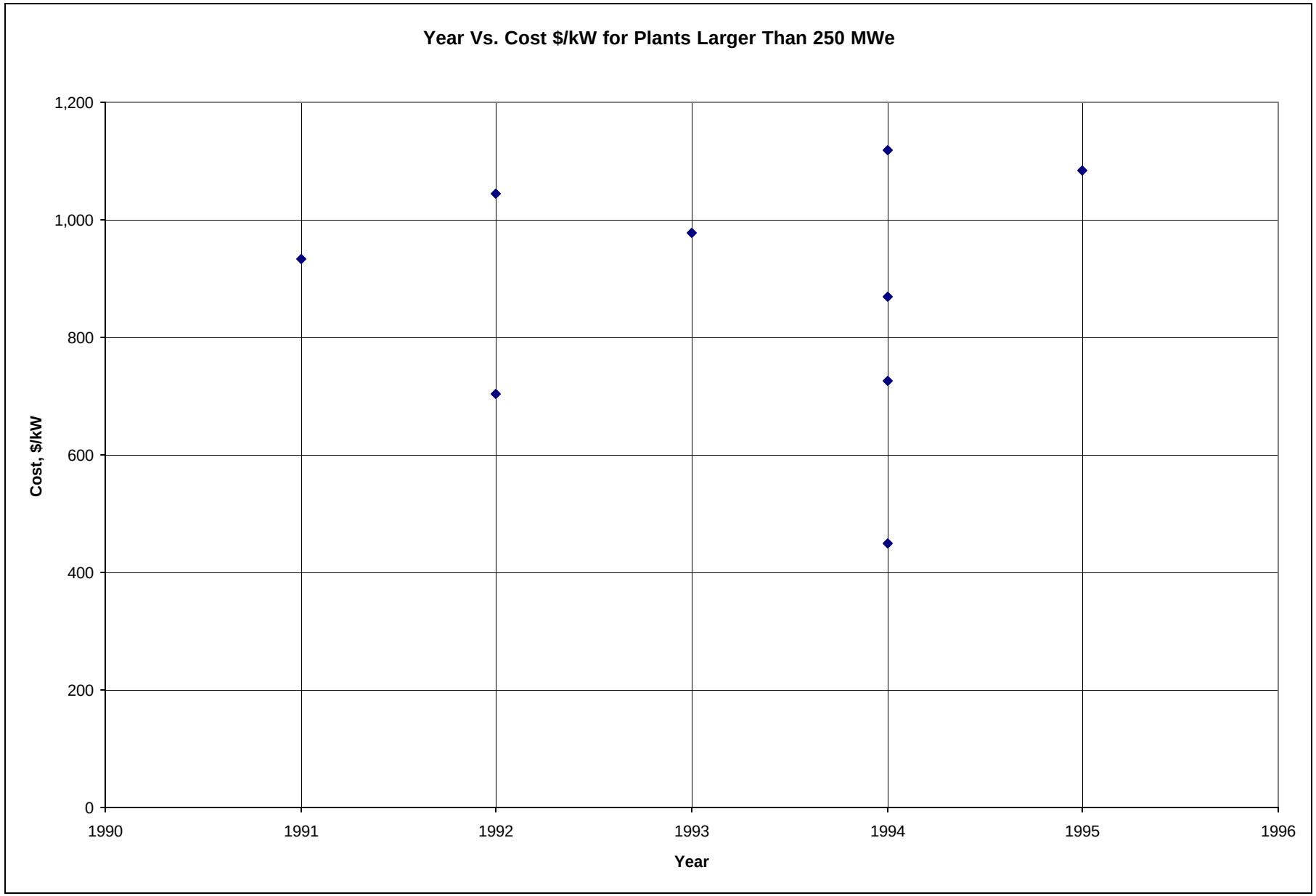
Year Vs. Cost $/kW for Plants Larger Than 250 MWe
Cost, $/kW
1,200
1,000
800
600
400
200
0
1990
1991
1992
1993
1994
1995
1996
Year

Figure 8

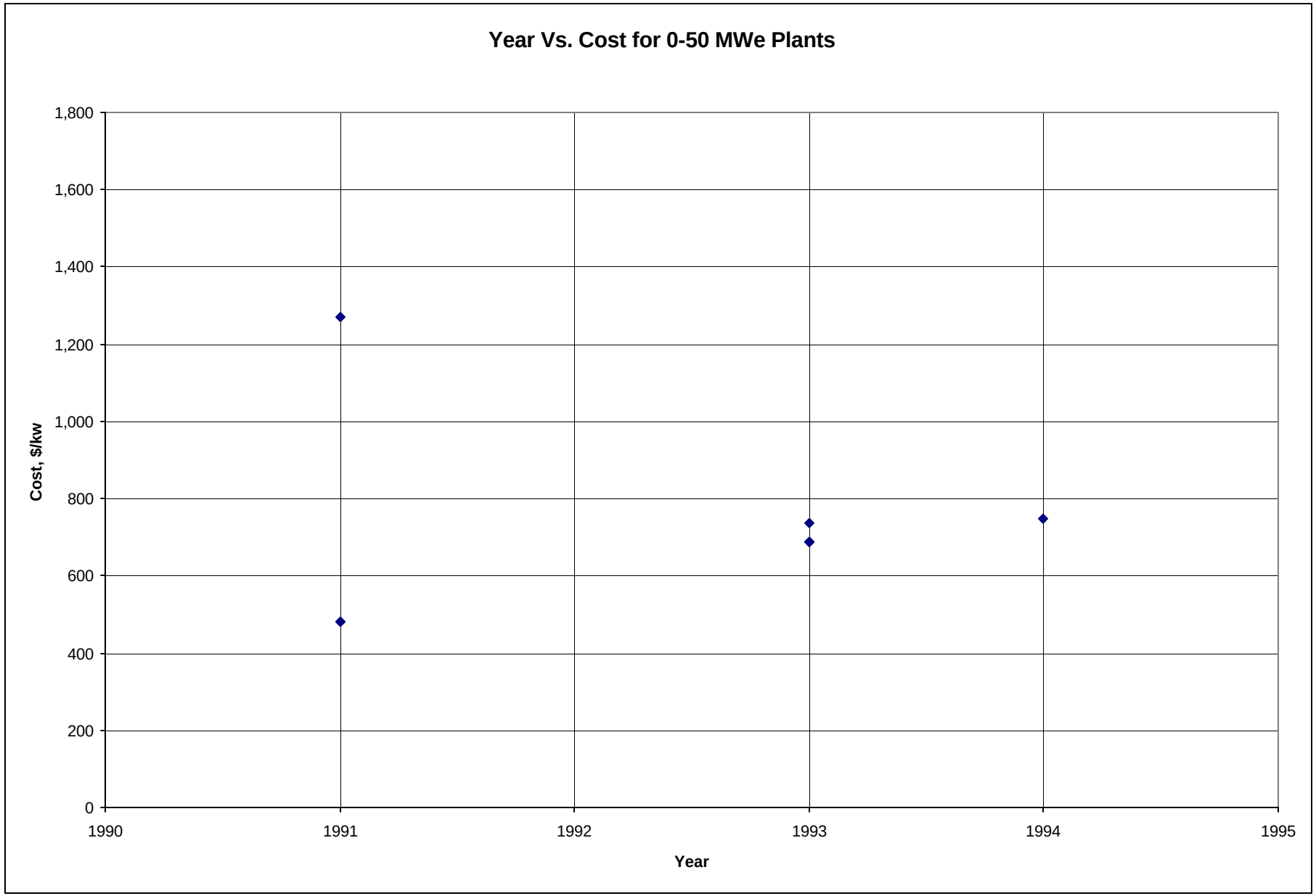
Year Vs. Cost for 0-50 MWe Plants
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Cost, $/kw
1990
1991
1992
1993
1994
1995
Year

Figure 9

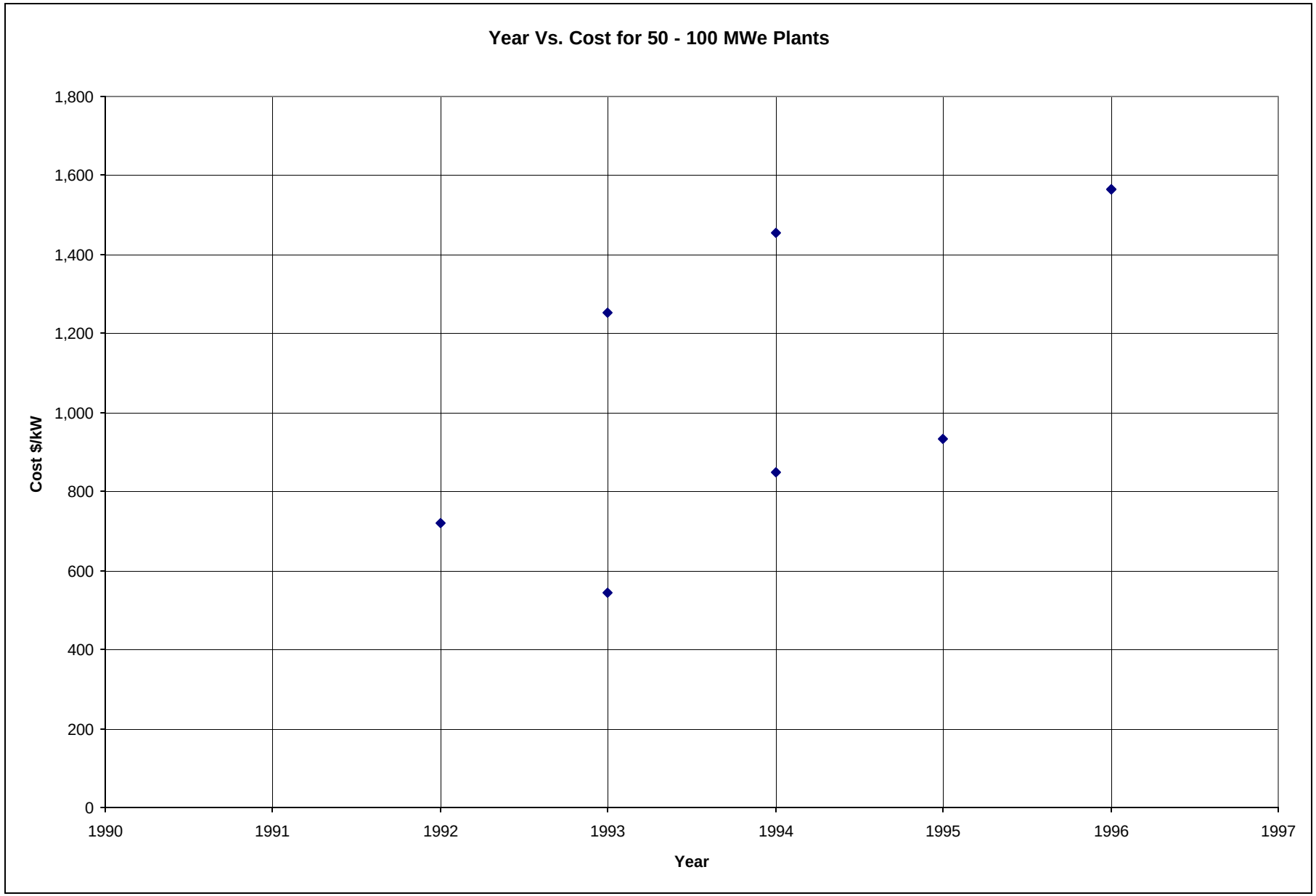
Year Vs. Cost for 50 - 100 MWe Plants
Cost $/kW
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1990
1991
1992
1993
1994
1995
1996
1997
Year

Figure 10

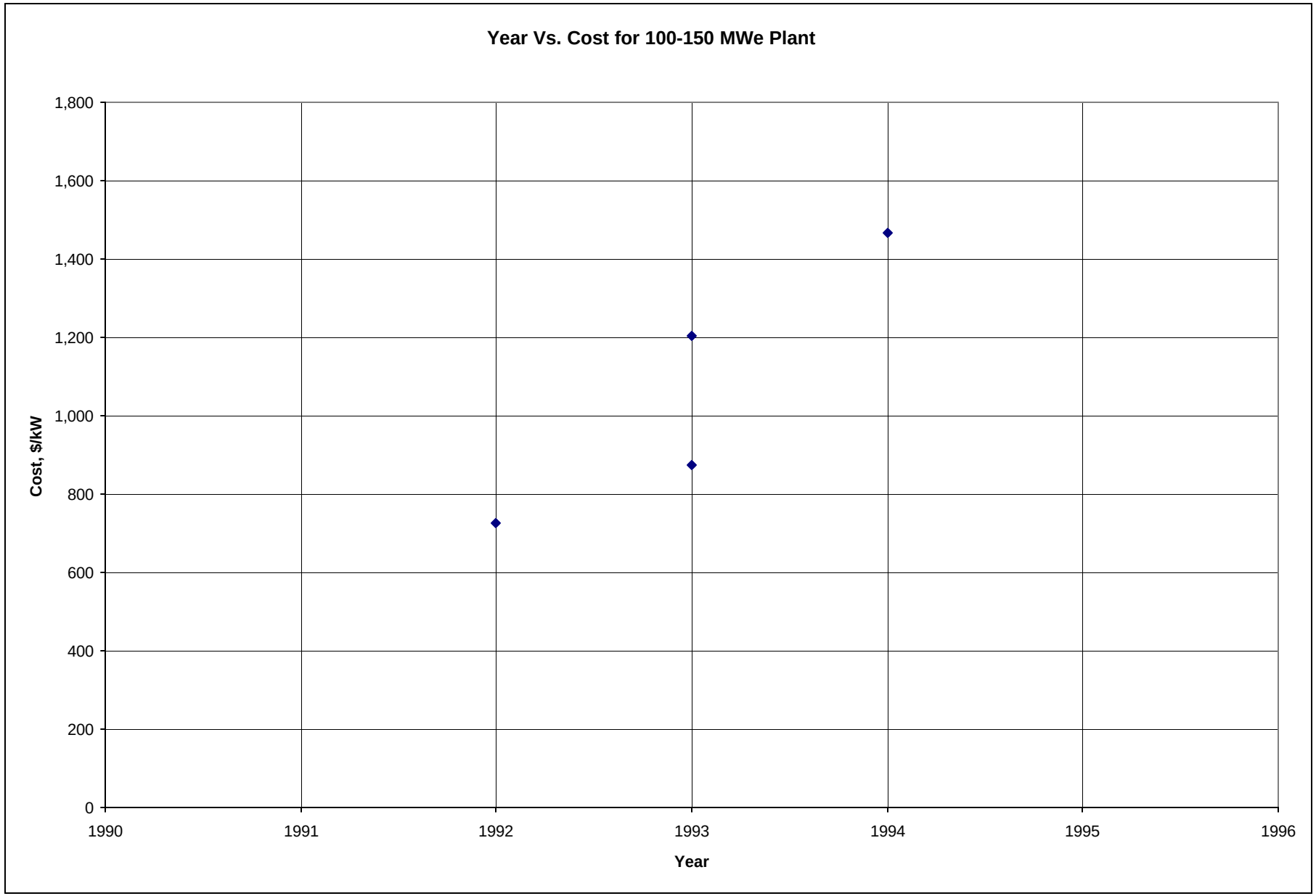
Year Vs. Cost for 100-150 MWe Plant
Cost, $/kW
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1990
1991
1992
1993
1994
1995
1996
Year

Figure 11

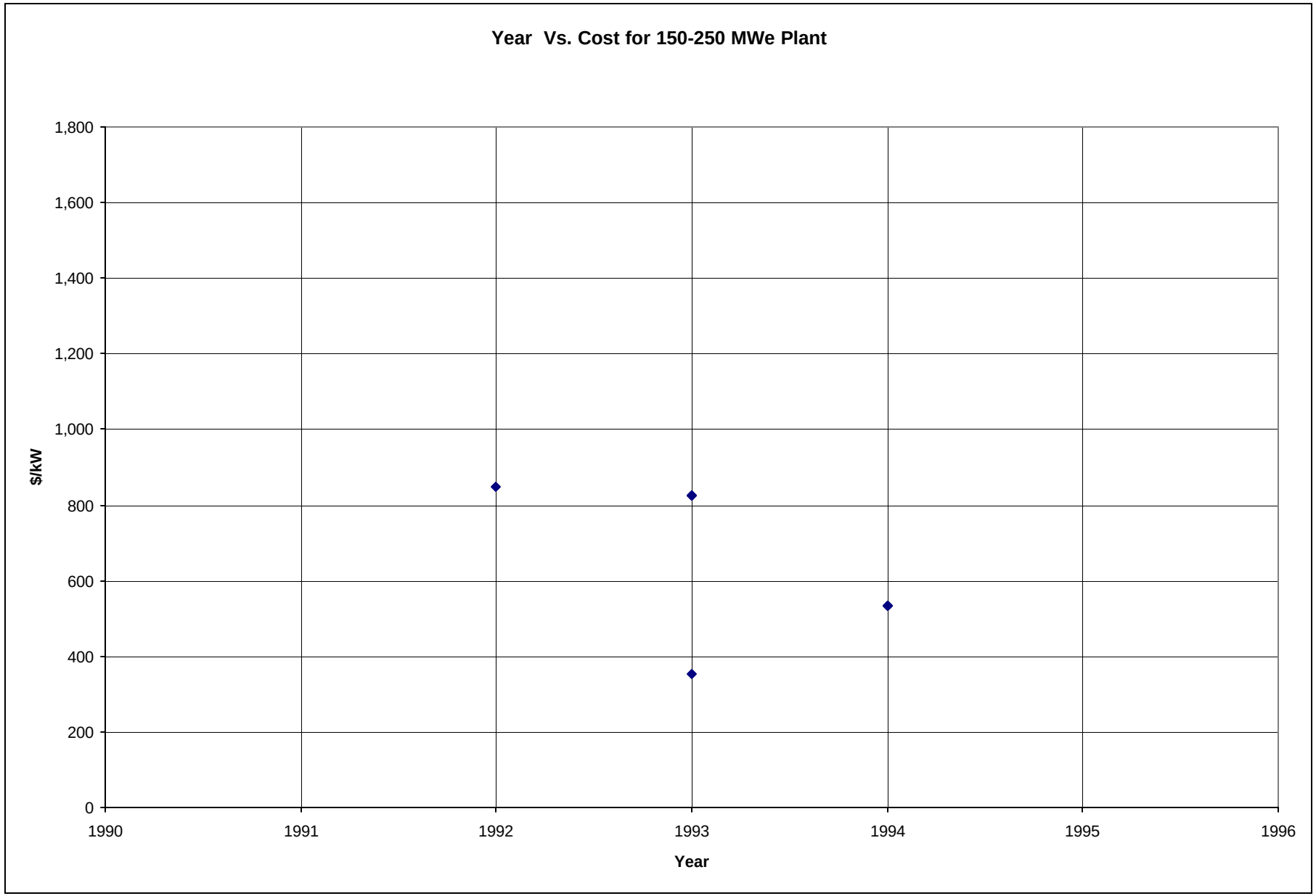
Year Vs. Cost for 150-250 MWe Plant
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
$/kW
1990
1991
1992
1993
1994
1995
1996
Year

Figure 12

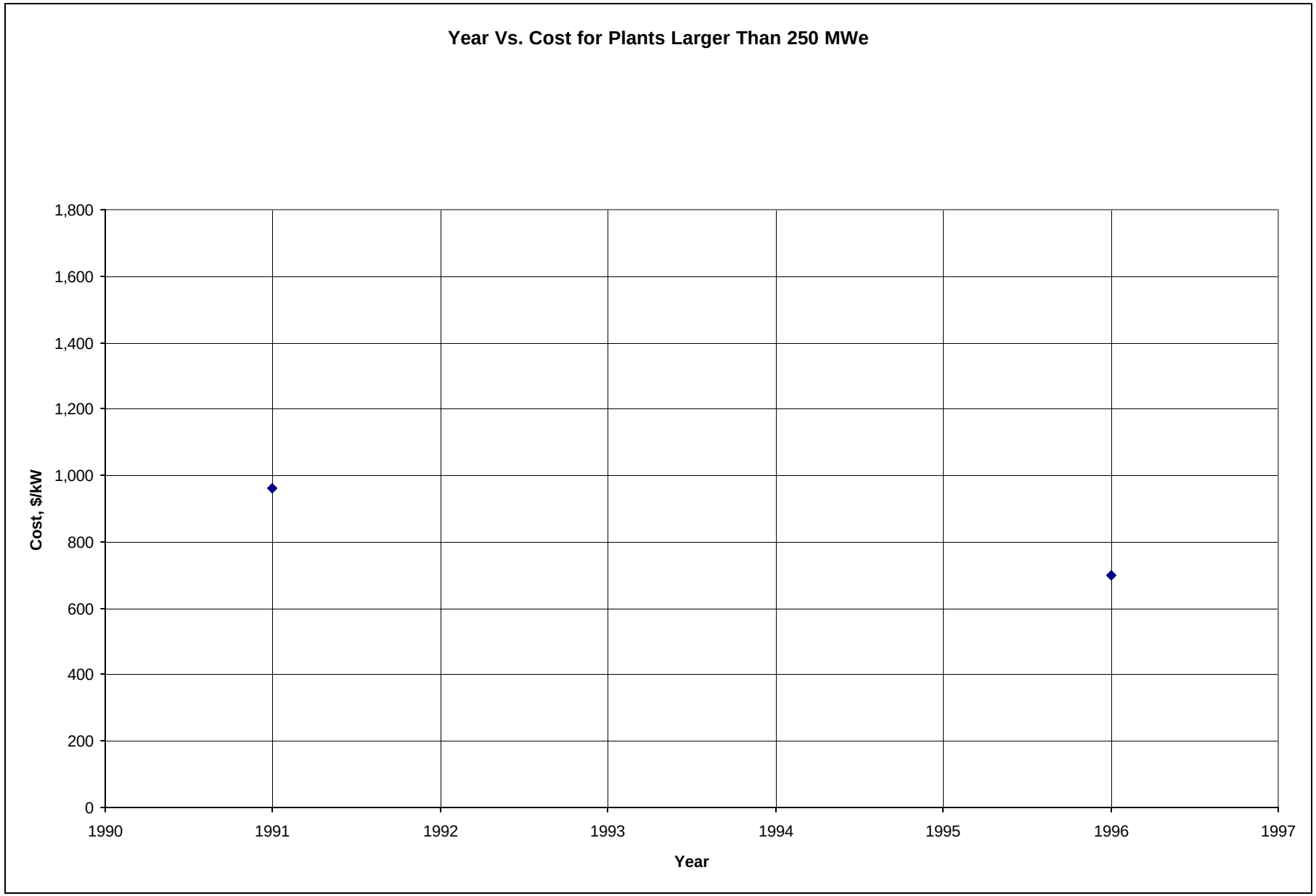
Year Vs. Cost for Plants Larger Than 250 MWe
Cost, $/kW
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1990
1991
1992
1993
1994
1995
1996
1997
Year

Figure 13

Regional Construction Labor Factors

Northeast	0.727802
Ohio River Valley	0.957854
Southeast	1.686341
Midwest	0.825764
Central	0.935454
South Central	1.347709
West Coast	0.809061
Northwest	0.94518
Hawaii	0.773395